National Aeronautics and Space Administration

2013–2014 NASA Student Launch

Note: For your convenience, this document identifies Web links when available. These links are correct as of this publishing; however, since Web links can be moved or disconnected at any time, we have also provided source information as available to assist you in locating the information.

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Timeline for NASA Student Launch

(Dates are subject to change.)

November 2013:

8	Request for Proposal (RFP) goes out to all teams.
22	Send electronic copy of completed proposal due by 8:00 a.m. Central Time to:

edward.m.jeffries@nasa.gov
Jacobs ESSSA Group

and to

julie.d.clift@nasa.gov
NASA MSFC

26	Teams notified of selection

December 2013:

3	Team teleconference
	Preliminary Design Review (PDR) Question and Answer Session
6	Web presence established for each team

January 2014:

10	PDR reports, presentation slides, and flysheet posted on the team Web site by 8:00 a.m. Central Time.
13–17	PDR Presentations
23	Critical Design Review (CDR) Question and Answer Session

February 2014:

28	CDR reports, presentation slides, and flysheet posted on the team Web site by 8:00 a.m. Central Time.

March 2014:

3–7	CDR Presentations
13	Flight Readiness Review (FRR) Question and Answer Session

April 2013:

18	FRR reports, presentation slides, and flysheet posted on the team Web site by 8:00 a.m. Central Time.
21–25	Flight Readiness Review Presentations

May 2014:

14	5:00 p.m.: All teams and team members arrive in Salt Lake City, Utah
	5:30 p.m.: Team Lead meeting
	6:30 p.m.: Launch Readiness Reviews (LRR) begin
15–16	Launch Readiness Reviews
17	Launch Day
18	Backup Rain Day

June 2014:

2	Post-Launch Assessment Review (PLAR) posted on the team Web site by 8:00 a.m. Central Time.
13	Winning team announced.

Design, Development, and Launch of a Reusable Rocket and Payload Statement of Work (SOW)

1. **Project Name: NASA Student Launch**

2. **Governing Office: NASA Marshall Space Flight Center Academic Affairs Office**

3. **Period of Performance: Eight (8) calendar months.**

4. **Introduction**

   The NASA Student Launch is a research-based, competitive and experiential exploration project that provides relevant and cost effective research and development to support the Space Launch System (SLS). Additionally, NASA Student Launch connects learners, educators and communities in NASA-unique opportunities that align with STEM Challenges under the NASA Education STEM Engagement line of business. NASA's missions, discoveries, and assets provide opportunities for students that do not exist elsewhere. The project involves reaching a broad audience of colleges and universities across the nation in an 8-month commitment to design, build, and fly payloads or vehicle components that support SLS on high power rockets to an altitude determined by the Range Safety Officer and each team's research needs. Supported by the Human Exploration and Operations (HEO) Mission Directorate and U.S. aerospace industry, NASA Student Launch is a NASA-conducted engineering design challenge to provide resources and experiences for students and faculty that is built around a NASA mission, not textbook knowledge. Research/investigation topics are conceived by the SLS Program office in collaboration with SLS industry partners. Research results will be shared by the teams with NASA and utilized in future design/development of SLS and other projects.

   After a competitive proposal selection process, teams participate in a series of design reviews that are submitted to NASA via a team-developed website. These reviews mirror the NASA engineering design lifecycle, providing an experience that prepares students for the HEO workforce. Teams must complete a Preliminary Design Review (PDR), Critical Design Review (CDR), Flight Readiness Review (FRR), Launch Readiness Review (LRR) that includes a safety briefing, and analyze payload and flight data during a Post Launch Assessment Review (PLAR). Teams present their PDR, CDR, and FRR to a review panel of scientists, engineers, technicians, and educators via WebEx technology. Review panel members, the Range Safety Officer (RSO), and Subject Matter Experts (SME) provide feedback and ask questions in order to increase the fidelity between the student payloads and HEO research needs, and score each team according to a standard scoring rubric.

The performance targets for the reusable launch vehicle and payload are

1. **Vehicle Requirements**
   - 1.1. The vehicle shall deliver the research payload to a predetermined altitude appropriate for the associated payload.
     - 1.1.1. The target altitude shall not exceed 20,000 feet above ground level.
     - 1.1.2. The final target altitude will be approved by the Range Safety Officer and Review Panel no later than PDR.

1.2. The vehicle shall carry one commercially available, barometric altimeter for recording the official altitude used in the competition scoring. Teams will be ranked according to the difference between the team's target altitude and the actual altitude earned during the official launch. The team with the least variance in target and actual altitudes will be ranked highest. The team with the largest variance will be ranked lowest. The highest rank will earn the full 100 points toward the altitude portion of the competition. The next highest rank will earn 97 out of the full 100 points, with each successive lower rank earning 3 points less than the next highest rank.

1.2.1. The official scoring altimeter shall report the official competition altitude via a series of beeps to be checked after the competition flight.

1.2.2. Teams may have additional altimeters to control vehicle electronics and payload experiments.

1.2.2.1. At the Launch Readiness Review, a NASA official will mark the altimeter that will be used for the official scoring.

1.2.2.2. At the launch field, a NASA official will obtain the altitude by listening to the audible beeps reported by the official competition, marked altimeter.

1.2.2.3. At the launch field, to aid in determination of the vehicle's apogee, all audible electronics, except for the official altitude-determining altimeter shall be capable of being turned off.

1.2.3. The following circumstances will warrant a score of zero for the altitude portion of the competition:

1.2.3.1. The official, marked altimeter is damaged and/or does not report an altitude via a series of beeps after the team's competition flight.

1.2.3.2. The team does not report to the NASA official designated to record the altitude with their official, marked altimeter on the day of the launch.

1.2.3.3. The altimeter reports an apogee altitude over 20,000 feet AGL.

1.2.3.4. The rocket is not flown at the competition launch site.

1.3. The launch vehicle shall be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.

1.4. The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the Federal Aviation Administration flight waiver opens.

1.5. The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any critical on-board component.

1.6. The launch vehicle shall be capable of being launched by a standard 12 volt direct current firing system. The firing system will be provided by the NASA-designated Range Services Provider.

1.7. The launch vehicle shall require no external circuitry or special ground support equipment to initiate launch (other than what is provided by Range Services).

1.8. The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR).

1.9. Pressure vessels on the vehicle shall be approved by the RSO and shall meet the following criteria:
   - 1.9.1. The minimum factor of safety (Burst or Ultimate pressure versus Max Expected Operating Pressure) shall be 4:1 with supporting design documentation included in all milestone reviews.
   - 1.9.2. The low-cycle fatigue life shall be a minimum of 4:1.
   - 1.9.3. Each pressure vessel shall include a pressure relief valve that sees the full pressure of the tank.
   - 1.9.4. Full pedigree of the tank shall be described, including the application for which the tank was designed, and the history of the tank, including the number of pressure cycles put on the tank, by whom, and when.

1.10. All teams shall successfully launch and recover their full scale rocket prior to FRR in its final flight configuration. The purpose of the full scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. The following criteria must be met during the full scale demonstration flight:
   - 1.10.1. The vehicle and recovery system shall have functioned as designed.

   - 1.10.2. The payload does not have to be flown during the full-scale test flight. The following requirements still apply:
      - 1.10.2.1. If the payload is not flown, mass simulators shall be used to simulate the payload mass.
         - 1.10.2.1.1. The mass simulators shall be located in the same approximate location on the rocket as the missing payload mass.

      - 1.10.2.2. If the payload changes the external surfaces of the rocket (such as with camera housings or external probes) or manages the total energy of the vehicle, those systems shall be active during the full scale demonstration flight.

   - 1.10.3. The full scale motor does not have to be flown during the full scale test flight. However, it is recommended that the full scale motor be used to demonstrate full flight readiness and altitude verification. If the full scale motor is not flown during the full scale flight, it is desired that the motor simulate, as closely as possible, the predicted maximum velocity and maximum acceleration of the competition flight.

   - 1.10.4. The vehicle shall be flown in its fully ballasted configuration during the full scale test flight. Fully ballasted refers to the same amount of ballast that will be flown during the competition flight.

   - 1.10.5. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components shall not be modified without the concurrence of the NASA Range Safety Officer (RSO).

2. Recovery System Requirements

2.1. The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude. Tumble recovery or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue-stage descent is reasonable, as deemed by the Range Safety Officer.

2.2. The parachute system(s) shall be designed and manufactured by the team. Commercially available parachute systems shall not be used on the vehicle.

2.3. At landing, each independent sections of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf.

2.4. The recovery system electrical circuits shall be completely independent of any payload electrical circuits.

2.5. The recovery system shall contain redundant, commercially available altimeters. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.

2.6. Each altimeter shall be armed by a dedicated arming switch which is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.

2.7. Each altimeter shall have a dedicated power supply.

2.8. Each arming switch shall be capable of being locked in the ON position for launch.

2.9. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.

2.10. An electronic tracking device shall be installed in the launch vehicle and shall transmit the position of the tethered vehicle or any independent section to a ground receiver.

- 2.10.1. Any rocket section, or payload component, which lands untethered to the launch vehicle shall also carry an active electronic tracking device.
- 2.10.2. The electronic tracking device shall be fully functional during the official flight at the competition launch site.

2.11. The recovery system electronics shall not be adversely affected by any other on-board electronic devices during flight (from launch until landing).

- 2.11.1. The recovery system altimeters shall be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.
- 2.11.2. The recovery system electronics shall be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system electronics.
- 2.11.3. The recovery system electronics shall be shielded from all onboard devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.
- 2.11.4. The recovery system electronics shall be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.

3. Payload Requirements

3.1. Each team shall design, test, and fly a payload package to support the development of SLS technology which meets the following required criteria at a minimum:

- 3.1.1. The payload shall incorporate a camera system that scans the surface during descent in order to detect potential landing hazards.
- 3.1.2. The data from the hazard detection camera shall be analyzed in real time by a custom designed on-board software package that shall determine if landing hazards are present.
- 3.1.3. The data from the surface hazard detection camera and software system shall be transmitted in real time to a ground station.

3.2. The payload shall be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.

3.3. Each team shall incorporate one payload option from each of the following columns in addition to the required payload from requirement 3.1.

3.2.1.1. Research and analysis of solid propellant rocket motors for in line and parallel staging. 3.2.1.2. Liquid sloshing research in microgravity to support liquid propulsion system upgrades and development. 3.2.1.3. Structural and dynamic analysis of airframe, propulsion, and electrical systems during boost. 3.2.1.4. Human and environmental studies under high acceleration to support Launch Abort System development. 3.2.1.5. Reduced Gravity Education Flight Program Option (see Requirement 3.4).	3.2.2.1. Payload fairing design and deployment mechanisms. 3.2.2.2. Aerodynamic analysis of structural protuberances. 3.2.2.3. Studies of triboelectric charging and effect on vehicle subsystems. 3.2.2.4. Environmental effects of supersonic flight on vehicle paint/coatings.

3.4. NASA Student Launch is partnering with the NASA Reduced Gravity Education Flight Program (RGEFP) to offer a chance for one team to fly a micro gravity payload on the reduced gravity aircraft. See the RGEFP website for more details: http://microgravityuniversity.jsc.nasa.gov/. The team chosen to participate will demonstrate the highest level of fidelity in meeting the following requirements:

- 3.4.1. The team participating in NASA Student Launch may be of any size, but the team during the RGEFP event is limited to 6 flyers (5 prime, 1 alternate) and 2 ground crew personnel. Team members shall be 18 years or older and US Citizens. Each flight crew member shall fly once.
- 3.4.2. Student experiments shall be organized, designed, and operated by student team members alone.
- 3.4.3. The payload shall be designed to fly on a Student Launch rocket, yet be scalable to fly on the RGEFP aircraft.
- 3.4.4. Payloads shall not involve human test subjects or invertebrate animals.
- 3.4.5. The payload shall be designed to fly twice on the reduced gravity aircraft.
- 3.4.6. The payload on the RGEFP aircraft shall weigh no more than 200 pounds.
- 3.4.7. The payload size limit on the RGEFP aircraft shall be no more than 24 in. by 60 in. by 60 in.
- 3.4.8. Payload experiments that are free-floating (not secured to the aircraft) shall be no more than 50 pounds and 24 in. on any side.
- 3.4.9. The selected team shall complete a medical questionnaire, flight program paperwork, Test Equipment Data Package six weeks prior to the flight, complete the Test Readiness Review, and spend 8 business days in Houston, Texas, for flight week activities.
- 3.4.10. Foreign nationals will not be able to participate in flight week activities.

4. General Requirements

4.1. Each team shall use a launch and safety checklist. The final checklists shall be included in the FRR report and used during the Launch Readiness Review and launch day operations.

4.2. Students on the team shall do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor).

4.3. The team shall provide and maintain a project plan to include, but not limited to the following items: project milestones, budget and community support, checklists, personnel assigned, educational engagement events, and risks and mitigations.

4.4. Each team shall identify a "mentor" which is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year, and may or may not be affiliated with the school, institution, or organization. The mentor shall have been certified by the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle, and the rocketeer shall have flown and successfully recovered (using electronic, staged recovery) a minimum of 2 flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to the launch at the competition launch site. One travel stipend will be provided per mentor regardless of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team attends launch week in May.

4.5. The team shall identify all team members (exception Foreign National team members — see item 4.6) attending launch week activities by the Critical Design Review (CDR). Team members shall include:

- 4.5.1. Students actively engaged in the project throughout the entire year and currently enrolled in the proposing institution.
- 4.5.2. One mentor (see requirement 4.4).
- 4.5.3. No more than two adult educators.

4.6. Foreign National (FN) team members shall be identified by the Preliminary Design Review (PDR) and may or may not have access to certain activities during launch week due to security restrictions. In addition, FN's may be separated from their team during these activities.

4.7. During test flights, teams shall abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch competition launch does not give explicit or implicit authority for teams to fly those certain vehicle configurations and/or payloads at other club launches. Teams should communicate their intentions to the local club's Prefect and RSO before attending any NAR or TRA launch.

4.8. The team shall engage a minimum of 200 participants (at least 100 of those shall be middle school students or educators) in educational, hands-on science, technology, engineering, and mathematics (STEM) activities, as defined in the Educational Engagement form, by FRR. An educational engagement form shall be completed and submitted within two weeks after completion of an event. A sample of the educational engagement form can be found on page 29 of the handbook.

4.9. The team shall develop and host a Web site for project documentation.
    4.9.1. Teams shall post, and make available for download, the required deliverables to the team Web site by the due dates specified in the project timeline.

At a minimum, the proposing team shall identify the following in a written proposal due to NASA MSFC by the dates specified in the project timeline.

General Information – to be included on the first page of the proposal.

1. Name of college or university, mailing address, and title of the project.

2. List of selected payloads with brief description and requirement numbers identified.

3. Name, title, and contact information for up to two adult educators.

4. Name and title of the individual who will take responsibility for implementation of the safety plan. (Safety Officer)

5. Name, title, and contact information for the student team leader.

6. Approximate number of student participants who will be committed to the project and their proposed duties. Include an outline of the project organization that identifies the key managers (students and/or educator administrators) and the key technical personnel. Only use first names for identifying team members; do not include surnames. (See requirement 4.5 and 4.6 for definition of team members)

7. Name of the NAR/TRA section(s) the team is associating with for launch assistance, mentor and review.

Facilities/Equipment

1. Description of facilities and hours of accessibility, necessary personnel, equipment, and supplies that are required to design and build a rocket and payload.

2. Computer Equipment: Describe the type of computer equipment accessible to the team for communications, designing, building and hosting a team Web site, and document development to support design reviews. The team shall provide and maintain a Web presence where the status of the project will be posted, as well as a list of needed materials and/or expertise. The team will provide the capability to communicate via e-mail on a daily basis with the NASA Student Launch Office. The information technology identified could include computer hardware, computer-aided drafting (CAD) system capability, Internet access, and e-mail capability.

   The team shall provide additional computer equipment needed to perform video teleconferencing. Minimum requirements include the following:
   - ❑ Windows, Mac, Linux, Unix, or Solaris computer systems.
   - ❑ Broadband internet connection.
   - ❑ Speakerphone capabilities in close proximity to the computer.
     Cellular phones are not recommended for use as a speakerphone.
   - ❑ USB Webcam or analog video camera.
   - ❑ Personal name and contact information for connectivity issues.

3. Teams must implement the Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194)

   Subpart B-Technical Standards (http://www.section508.gov):
   - ❑ 1194.21 Software applications and operating systems. (a-l)
   - ❑ 1194.22 Web-based intranet and internet information and applications. 16 rules (a-p)
   - ❑ 1194.26 Desktop and portable computers. (a-d)

Safety

The Federal Aviation Administration (FAA) [www.faa.gov] has specific laws governing the use of airspace. A demonstration of the understanding and intent to abide by the applicable federal laws (especially as related to the use of airspace at the launch sites and the use of combustible/ flammable material), safety codes, guidelines, and procedures for building, testing, and flying large model rockets is crucial. The procedures and safety regulations of the NAR [http://www.nar.org/safety.html] should be used for flight design and operations. The NAR/TRA mentor and Safety Officer shall oversee launch operations and motor handling.

1. Provide a written safety plan addressing the safety of the materials used, facilities involved, and person responsible, i.e., Safety Officer, for insuring that the plan is followed. A risk assessment should be done for all these aspects in addition to proposed mitigations. Identification of risks to the successful completion of the project should be included.

2. Provide a description of the procedures for NAR/TRA personnel to perform. Ensure the following:
   - ❑ Compliance with NAR high power safety code requirements [http://nar.org/NARhpsc.html].
   - ❑ Performance of all hazardous materials handling and hazardous operations.

3. Describe the plan for briefing students on hazard recognition and accident avoidance, and conducting prelaunch briefings.

4. Describe methods to include necessary caution statements in plans, procedures and other working documents, including the use of proper Personal Protective Equipment.

5. Each team shall provide a plan for complying with federal, state, and local laws regarding unmanned rocket launches and motor handling. Specifically, regarding the use of airspace, Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; the handling and use of low-explosives (Ammonium Perchlorate Rocket Motors, APCP), Code of Federal Regulation 27 Part 55: Commerce in Explosives; and fire prevention, NFPA 1127 “Code for High Power Rocket Motors.”

6. Provide a plan for NRA/TRA mentor purchase, store, transport, and use rocket motors and energetic devices.

7. A written statement that all team members understand and will abide by the following safety regulations:
   a. Range safety inspections of each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program.
   b. The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.
   c. Any team that does not comply with the safety requirements will not be allowed to launch their rocket.

Technical Design

1. A proposed and detailed approach to rocket and payload design.
    a. Include general vehicle dimensions, material selection and justification, and construction methods.
    b. Include projected altitude and justification.
    c. Include projected parachute system design and manufacturing process.
    d. Include projected motor type and size.
    e. Include projected payloads with hypothesis and/or stated goal for said payload.
        - For teams pursuing the RGEFP payload option, include the following:
            - Address how the payload will be scaled up to take full advantage of the space available on the microgravity flight.
            - Define the researcher's interactions/procedures with the payload during the microgravity flight.
            - Identify potential hazards or safety concerns and the associated mitigation plans.
    f. Address the requirements for the vehicle, recovery system, and payload.
    g. Address major technical challenges and solutions.

Educational Engagement

1. Include plans for required educational engagement activities (See requirement 4.8). Plans for measuring event success shall be included.

Project Plan

1. Provide a detailed development schedule/timeline covering all aspects necessary to successfully complete the project.

2. Provide a detailed budget to cover all aspects necessary to successfully complete the project including team travel to launch.

3. Provide a detailed funding plan.

4. Provide a written plan for soliciting additional "community support," which could include, but is not limited to, expertise needed, additional equipment/supplies, sponsorship, services (such as free shipping for launch vehicle components, if required, advertisement of the event, etc.), or partnering with industry or other public or private schools.

5. Address major programmatic challenges and solutions.

6. Develop a clear plan for sustainability of the rocket project in the local area. This plan should include how to provide and maintain established partnerships and regularly engage successive classes of students in rocketry. It should also include partners (industry/community), recruitment of team members, funding sustainability, and educational engagement.

Prior to award, all proposing entities may be required to brief NASA representatives. The time and the place for the briefings will be determined by the NASA MSFC Academic Affairs Office.

Deliverables shall include:

1. A reusable rocket and required payload systems ready for the official launch.

2. A scale model of the rocket design with a payload prototype. This model should be flown prior to the CDR. A report of the data from the flight and the model should be brought to the CDR.

3. Reports, PowerPoint presentations, and Milestone Review Flysheets due according to the provided timeline, and shall be posted on the team Web site by the due date. (Dates are tentative at this point. Final dates will be announced at the time of award.)

4. The team(s) shall have a Web presence no later than the date specified. The Web site shall be maintained/updated throughout the period of performance.

5. Electronic copies of the Educational Engagement form(s) and lessons learned pertaining to the implemented educational engagement activities shall be submitted prior to the FRR and no later than two weeks after the educational engagement event.

The team shall participate in a PDR, CDR, FRR, LRR, and PLAR. (Dates are tentative and subject to change.)

The PDR, CDR, FRR, and LRR will be presented to NASA at a time and/or location to be determined by NASA MSFC Academic Affairs Office.

Vehicle/Payload Criteria

Preliminary Design Review (PDR)
Vehicle and Payload Experiment Criteria

The PDR demonstrates that the overall preliminary design meets all requirements with acceptable risk, and within the cost and schedule constraints, and establishes the basis for proceeding with detailed design. It shows that the correct design options have been selected, interfaces have been identified, and verification methods have been described. Full baseline cost and schedules, as well as all risk assessment, management systems, and metrics, are presented.

The panel will be expecting a professional and polished report. It is advised to follow the order of sections as they appear below.

Preliminary Design Review Report

I) Summary of PDR report (1 page maximum)

Team Summary

- Team name and mailing address
- Location
- Name of mentor, NAR/TRA number and certification level

Launch Vehicle Summary

- Size and mass
- Motor choice
- Recovery system
- Milestone Review Flysheet

Payload Summary

- Payload title and selected payloads with requirement number
- Summarize experiment

II) Changes made since Proposal (1-2 pages maximum)

Highlight all changes made since the proposal and the reason for those changes.

- Changes made to vehicle criteria
- Changes made to payload criteria
- Changes made to project plan

III) Vehicle Criteria

Selection, Design, and Verification of Launch Vehicle

- Include a mission statement, requirements, and mission success criteria.
- Review the design at a system level, going through each system’s functional requirements (includes sketches of options, selection rationale, selected concept, and characteristics).
- Describe the subsystems that are required to accomplish the overall mission.
- Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.

- Describe the verification plan and its status. At a minimum, a table should be included that lists each requirement (in SOW), and for each requirement briefly describe the design feature that will satisfy that requirement and how that requirement will ultimately be verified (such as by inspection, analysis, and/or test).
- Define the risks and the plans for reducing the risks through analysis or testing for each system. A risk plot that clearly portrays the risk mitigation schedule is highly encouraged. Take all factors that might affect the project including risks associated with testing, delivery of parts, adequate personnel, school holidays, budget costs, etc. Demonstrate an understanding of all components needed to complete the project and how risks/delays impact the project.
- Demonstrate planning of manufacturing, verification, integration, and operations (include component testing, functional testing, or static testing).
- Describe the confidence and maturity of design.
- Include a dimensional drawing of entire assembly. The drawing set should include drawings of the entire launch vehicle, compartments within the launch vehicle (such as parachute bays, payload bays, and electronics bays), and significant structural design features of the launch vehicle (such as fins and bulkheads).
- Include electrical schematics for the recovery system.
- Include a Mass Statement. Discuss the estimated mass of the launch vehicle, its subsystems, and components. What is the basis of the mass estimate and how accurate is it? Discuss how much margin there is before the vehicle becomes too heavy to launch with the identified propulsion system. Are you holding any mass in reserve (i.e., are you planning for any mass growth as the design matures)? If so, how much? As a point of reference, a reasonable rule of thumb is that the mass of a new product will grow between 25 and 33% between PDR and the delivery of the final product.

Recovery Subsystem

- Demonstrate that analysis has begun to determine size for mass, attachment scheme, deployment process, and test results/plans with ejection charges and electronics.
- Discuss the major components of the recovery system (such as the parachutes, parachute harnesses, attachment hardware, and bulkheads), and verify that they will be robust enough to withstand the expected loads.

Mission Performance Predictions

- State mission performance criteria.
- Show flight profile simulations, altitude predictions with simulated vehicle data, component weights, and simulated motor thrust curve, and verify that they are robust enough to withstand the expected loads.
- Show stability margin, simulated Center of Pressure (CP)/Center of Gravity (CG) relationship and locations.
- Calculate the kinetic energy at landing for each independent and tethered section of the launch vehicle.
- Calculate the drift for each independent section of the launch vehicle from the launch pad for five different cases: no wind, 5-mph wind, 10-mph wind, 15-mph wind, and 20-mph wind.

Interfaces and Integration

- Describe payload integration plan with an understanding that the payload must be co-developed with the vehicle, be compatible with stresses placed on the vehicle, and integrate easily and simply.
- Describe the interfaces that are internal to the launch vehicle, such as between compartments and subsystems of the launch vehicle.
- Describe the interfaces between the launch vehicle and the ground (mechanical, electrical, and/or wireless/transmitting).
- Describe the interfaces between the launch vehicle and the ground launch system.

Launch Operation Procedures

- Develop a checklist of final assembly and launch procedures.

Safety and Environment (Vehicle)

- Identify a safety officer for your team.
- Provide a preliminary analysis of the failure modes of the proposed design of the rocket, payload integration, and launch operations, including proposed and completed mitigations.
- Provide a listing of personnel hazards and data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.
- Discuss any environmental concerns.

IV) Payload Criteria

Selection, Design, and Verification of Payload Experiment

- Review the design at a system level, going through each system's functional requirements (includes sketches of options, selection rationale, selected concept, and characteristics).
- Describe the payload subsystems that are required to accomplish the payload objectives.
- Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.
- Describe the verification plan and its status. At a minimum, a table should be included that lists each payload requirement and for each requirement briefly describe the design feature that will satisfy that requirement and how that requirement will ultimately be verified (such as by inspection, analysis, and/or test).
- Describe preliminary integration plan.
- Determine the precision of instrumentation, repeatability of measurement, and recovery system.
- Include drawings and electrical schematics for the key elements of the payload.
- Discuss the key components of the payload and how they will work together to achieve the desired results for the experiment.

Payload Concept Features and Definition

- Creativity and originality
- Uniqueness or significance
- Suitable level of challenge

Science Value

- Describe payload objectives.
- State the payload success criteria.
- Describe the experimental logic, approach, and method of investigation.
- Describe test and measurement, variables, and controls.
- Show relevance of expected data and accuracy/error analysis.
- Describe the preliminary experiment process procedures.

Safety and Environment (Payload)

- Identify safety officer for your team.
- Provide a preliminary analysis of the failure modes of the proposed design of the rocket, payload integration, and launch operations, including proposed and completed mitigations.
- Provide a listing of personnel hazards and data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.
- Discuss any environmental concerns.

V) Project Plan

Show status of activities and schedule

- Budget plan (in as much detail as possible)
- Funding plan
- Timeline (in as much detail as possible). GANTT charts are encouraged with a discussion of the critical path.
- Educational engagement plan and status

VI) Conclusion

Preliminary Design Review Presentation

Please include the following in your presentation:

- Vehicle dimensions, materials, and justifications
- Static stability margin
- Plan for vehicle safety verification and testing
- Baseline motor selection and justification
- Thrust-to-weight ratio and rail exit velocity
- Launch vehicle verification and test plan overview
- Drawing/Discussion of each major component and subsystem, especially the recovery subsystem
- Baseline payload design
- Payload verification and test plan overview

The PDR will be presented to a panel that may be comprised of any combination of scientists, engineers, safety experts, education specialists, and industry partners. This review should be viewed as the opportunity to convince the NASA Review Panel that the preliminary design will meet all requirements, has a high probability of meeting the mission objectives, and can be safely constructed, tested, launched, and recovered. Upon successful completion of the PDR, the team is given the authority to proceed into the final design phase of the life cycle that will culminate in the Critical Design Review.

It is expected that the **students** deliver the report and answer all questions.

The presentation of the PDR shall be well prepared with a professional overall appearance. This includes, but is not limited to, the following: easy-to-see slides; appropriate placement of pictures, graphs, and videos; professional appearance of the presenters; speaking clearly and loudly; looking into the camera; referring to the slides, not reading them; and communicating to the panel in an appropriate and professional manner. The slides should use dark text on a light background.

Critical Design Review (CDR)
Vehicle and Payload Experiment Criteria

The CDR demonstrates that the maturity of the design is appropriate to support proceeding to full-scale fabrication, assembly, integration, and test and that the technical effort is on track to complete the flight and ground system development and mission operations in order to meet overall performance requirements within the identified cost schedule constraints. Progress against management plans, budget, and schedule, as well as risk assessment, are presented. The CDR is a review of the final design of the launch vehicle and payload system. All analyses should be complete and some critical testing should be complete. The CDR Report and Presentation should be independent of the PDR Report and Presentation. However, the CDR Report and Presentation may have the same basic content and structure as the PDR documents, but with final design information that may or may not have changed since PDR. Although there may be discussion of subscale models, the CDR documents are to primarily discuss the final design of the full scale launch vehicle and subsystems.

The panel will be expecting a professional and polished report. It is advised to follow the order of sections as they appear below.

Critical Design Review Report

I) Summary of CDR report (1 page maximum)

Team Summary

- Team name and mailing address
- Location
- Name of mentor, NAR/TRA number and certification level

Launch Vehicle Summary

- Size and mass
- Motor choice
- Recovery system
- Rail size
- Milestone Review Flysheet

Payload Summary

- Payload title and selected payloads with requirement number
- Summarize experiment

II) Changes made since PDR (1-2 pages maximum)

Highlight all changes made since PDR and the reason for those changes.

- Changes made to vehicle criteria
- Changes made to payload criteria
- Changes made to project plan

III) Vehicle Criteria

Design and Verification of Launch Vehicle

Flight Reliability and Confidence

- Include mission statement, requirements, and mission success criteria
- Include major milestone schedule (project initiation, design, manufacturing, verification, operations, and major reviews)
- Review the design at a system level
    - Final drawings and specifications
    - Final analysis and model results, anchored to test data
    - Test description and results
    - Final motor selection
- Demonstrate that the design can meet all system level functional requirements. For each requirement, state the design feature that satisfies that requirement and how that requirement has been, or will be, verified.
- Specify approach to workmanship as it relates to mission success.
- Discuss planned additional component, functional, or static testing.
- Status and plans of remaining manufacturing and assembly.
- Discuss the integrity of design.
    - Suitability of shape and fin style for mission
    - Proper use of materials in fins, bulkheads, and structural elements
    - Proper assembly procedures, proper attachment and alignment of elements, solid connection points, and load paths
    - Sufficient motor mounting and retention
    - Status of verification
    - Drawings of the launch vehicle, subsystems, and major components
    - Include a Mass Statement. Discuss the estimated mass of the final design and its subsystems and components. Discuss the basis and accuracy of the mass estimate, the expected mass growth between CDR and the delivery of the final product, and the sensitivity of the launch vehicle to mass growth (e.g., How much mass margin there is before the vehicle becomes too heavy to launch on the selected propulsion system?).
- Discuss the safety and failure analysis.

Subscale Flight Results

- Include actual flight data from onboard computers, if available.
- Compare the predicted flight model to the actual flight data. Discuss the results.
- Discuss how the subscale flight data has impacted the design of the full-scale launch vehicle.

Recovery Subsystem

- Describe the parachute, harnesses, bulkheads, and attachment hardware.
- Discuss the electrical components and how they will work together to safely recover the launch vehicle.
- Include drawings/sketches, block diagrams, and electrical schematics.
- Discuss the kinetic energy at significant phases of the mission, especially at landing.
- Discuss test results.
- Discuss safety and failure analysis.

Mission Performance Predictions

- State the mission performance criteria.
- Show flight profile simulations, altitude predictions with final vehicle design, weights, and actual motor thrust curve.
- Show thoroughness and validity of analysis, drag assessment, and scale modeling results.
- Show stability margin and the actual CP and CG relationship and locations.

Payload Integration

Ease of integration

- Describe integration plan.
- Installation and removal, interface dimensions, and precision fit.
- Compatibility of elements.
- Simplicity of integration procedure.

Launch concerns and operation procedures

- Submit draft of final assembly and launch procedures.
- Recovery preparation.
- Motor preparation.
- Igniter installation.
- Setup on launcher.
- Troubleshooting.
- Postflight inspection.

Safety and Environment (Vehicle)

- Identify safety officer for your team.
- Update the preliminary analysis of the failure modes of the proposed design of the rocket and payload integration and launch operations, including proposed, and completed mitigations.
- Update the listing of personnel hazards and data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.
- Discuss any environmental concerns.

IV) Payload Criteria

Testing and Design of Payload Experiment

- Review the design at a system level.
    - Drawings and specifications
    - Analysis results
    - Test results
    - Integrity of design
- Demonstrate that the design can meet all system-level functional requirements.
- Specify approach to workmanship as it relates to mission success.
- Discuss planned component testing, functional testing, or static testing.
- Status and plans of remaining manufacturing and assembly.
- Describe integration plan.
- Discuss the precision of instrumentation and repeatability of measurement.

- Discuss the payload electronics with special attention given to transmitters.
    - Drawings and schematics
    - Block diagrams
    - Batteries/power
    - Transmitter frequencies, wattage, and location
    - Test plans
- Provide a safety and failure analysis.

Payload Concept Features and Definition
- Creativity and originality
- Uniqueness or significance
- Suitable level of challenge

Science Value
- Describe payload objectives.
- State the payload success criteria.
- Describe the experimental logic, approach, and method of investigation.
- Describe test and measurement, variables, and controls.
- Show relevance of expected data and accuracy/error analysis.
- Describe the experiment process procedures.

Safety and Environment (Payload)
- Identify safety officer for your team.
- Update the preliminary analysis of the failure modes of the proposed design of the rocket and payload integration and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, and data demonstrating that safety hazards have been researched (such as material safety data sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

V) Project Plan

Show status of activities and schedule
- Budget plan (in as much detail as possible)
- Funding plan
- Timeline (in as much detail as possible). GANTT charts are encouraged with a discussion of the critical path.
- Educational engagement plan and status

VI) Conclusion

Critical Design Review Presentation

Please include the following information in your presentation:

- Final launch vehicle dimensions
- Discuss key design features
- Final motor choice
- Rocket flight stability in static margin diagram
- Thrust-to-weight ratio and rail exit velocity
- Mass Statement and mass margin
- Parachute sizes, recovery harness type, size, and length, and descent rates
- Kinetic energy at key phases of the mission, especially landing
- Predicted drift from the launch pad with 5-, 10-, 15-, and 20-mph wind
- Test plans and procedures
- Scale model flight test
- Tests of the staged recovery system
- Final payload design overview
- Payload integration
- Interfaces (internal within the launch vehicle and external to the ground)
- Status of requirements verification

The CDR will be presented to a panel that may be comprised of any combination of scientists, engineers, safety experts, education specialists, and industry partners. The team is expected to present and defend the final design of the launch vehicle (including the payload), showing that design meets the mission objectives and requirements and that the design can be safety, constructed, tested, launched, and recovered. Upon successful completion of the CDR, the team is given the authority to proceed into the construction and verification phase of the life cycle which will culminate in a Flight Readiness Review.

It is expected that the **students** deliver the report and answer all questions.

The presentation of the CDR shall be well prepared with a professional overall appearance. This includes, but is not limited to, the following: easy-to-see slides; appropriate placement of pictures, graphs, and videos; professional appearance of the presenters; speaking clearly and loudly; looking into the camera; referring to the slides, not reading them; and communicating to the panel in an appropriate and professional manner. The slides should be made with dark text on a light background.

Flight Readiness Review (FRR)

Vehicle and Payload Experiment Criteria

The FRR examines tests, demonstrations, analyses, and audits that determine the overall system (all projects working together) readiness for a safe and successful flight/launch and for subsequent flight operations of the as-built rocket and payload system. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready.

The panel will be expecting a professional and polished report. It is advised to follow the order of sections as they appear below.

Flight Readiness Review Report

I) Summary of FRR report (1 page maximum)

Team Summary

- Team name and mailing address
- Location
- Name of mentor, NAR/TRA number and certification level

Launch Vehicle Summary

- Size and mass
- Final motor choice
- Recovery system
- Rail size
- Milestone Review Flysheet

Payload Summary

- Payload title and selected payloads with requirement number
- Summarize experiment

II) Changes made since CDR (1-2 pages maximum)

Highlight all changes made since CDR and the reason for those changes.

- Changes made to vehicle criteria
- Changes made to payload criteria
- Changes made to project plan

III) Vehicle Criteria

Design and Construction of Vehicle

- Describe the design and construction of the launch vehicle, with special attention to the features that will enable the vehicle to be launched and recovered safely.
  - Structural elements (such as airframe, fins, bulkheads, attachment hardware, etc.).
  - Electrical elements (wiring, switches, battery retention, retention of avionics boards, etc.).
  - Drawings and schematics to describe the assembly of the vehicle.

- Discuss flight reliability confidence. Demonstrate that the design can meet mission success criteria. Discuss analysis, and component, functional, or static testing.
- Present test data and discuss analysis, and component, functional, or static testing of components and subsystems.
- Describe the workmanship that will enable mission success.
- Provide a safety and failure analysis, including a table with failure modes, causes, effects, and risk mitigations.
- Discuss full-scale launch test results. Present and discuss actual flight data. Compare and contrast flight data to the predictions from analysis and simulations.
- Provide a Mass Report and the basis for the reported masses.

Recovery Subsystem

- Describe and defend the robustness of as-built and as-tested recovery system.
  - Structural elements (such as bulkheads, harnesses, attachment hardware, etc.).
  - Electrical elements (such as altimeters/computers, switches, connectors).
  - Redundancy features.
  - Parachute sizes and descent rates
  - Drawings and schematics of the electrical and structural assemblies.
  - Rocket-locating transmitters with a discussion of frequency, wattage, and range.
  - Discuss the sensitivity of the recovery system to onboard devices that generate electromagnetic fields (such as transmitters). This topic should also be included in the Safety and Failure Analysis section.
- Suitable parachute size for mass, attachment scheme, deployment process, test results with ejection charge and electronics
- Safety and failure analysis. Include table with failure modes, causes, effects, and risk mitigations.

Mission Performance Predictions

- State mission performance criteria.
- Provide flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve. Include real values with optimized design for altitude. Include sensitivities.
- Thoroughness and validity of analysis, drag assessment, and scale modeling results. Compare analyses and simulations to measured values from ground and/or flight tests. Discuss how the predictive analyses and simulation have been made more accurate by test and flight data.
- Provide stability margin, with actual CP and CG relationship and locations. Include dimensional moment diagram or derivation of values with points indicated on vehicle. Include sensitivities.
- Discuss the management of kinetic energy through the various phases of the mission, with special attention to landing.
- Discuss the altitude of the launch vehicle and the drift of each independent section of the launch vehicle for winds of 0-, 5-, 10-, 15-, and 20-mph.

Verification (Vehicle)

- For each requirement (in SOW), describe how that requirement has been satisfied and by what method the requirement was verified. Note: Requirements are often satisfied by design features of a product, and requirements are usually verified by one or more of the following methods: analysis, inspection, and test.
- The verification statement for each requirement should include results of the analysis, inspection, and/or test which prove that the requirement has been properly verified.

Safety and Environment (Vehicle)

- Provide a safety and mission assurance analysis. Provide a Failure Modes and Effects Analysis (which can be as simple as a table of failure modes, causes, effects, and mitigations/controls put in place to minimize the occurrence or effect of the hazard or failure). Discuss likelihood and potential consequences for the top 5 to 10 failures (most likely to occur and/or worst consequences).
- As the program is moving into the operational phase of the Life Cycle, update the listing of personnel hazards, including data demonstrating that safety hazards that will still exist after FRR. Include a table which discusses the remaining hazards and the controls that have been put in place to minimize those safety hazards to the greatest extent possible.
- Discuss any environmental concerns that remain as the project moves into the operational phase of the life cycle.

Payload Integration

- Describe the integration of the payload into the launch vehicle.
- Demonstrate compatibility of elements and show fit at interface dimensions.
- Describe and justify payload-housing integrity.
- Demonstrate integration: show a diagram of components and assembly with documented process.

IV) Payload Criteria

Experiment Concept

This concerns the quality of science. Give clear, concise, and descriptive explanations.

- Creativity and originality
- Uniqueness or significance

Science Value

- Describe science payload objectives in a concise and distinct manner.
- State the mission success criteria.
- Describe the experimental logic, scientific approach, and method of investigation.
- Explain how it is a meaningful test and measurement, and explain variables and controls.
- Discuss the relevance of expected data, along with an accuracy/error analysis, including tables and plots.
- Provide detailed experiment process procedures.

Payload Design

- Describe the design and construction of the payload and demonstrate that the design meets all mission requirements.
    - Structural elements (such as airframe, bulkheads, attachment hardware, etc.).
    - Electrical elements (wiring, switches, battery retention, retention of avionics boards, etc.).
    - Drawings and schematics to describe the design and assembly of the payload.
- Provide information regarding the precision of instrumentation and repeatability of measurement (include calibration with uncertainty).
- Provide flight performance predictions (flight values integrated with detailed experiment operations).
- Specify approach to workmanship as it relates to mission success.
- Discuss the test and verification program.

Verification

- For each payload requirement, describe how that requirement has been satisfied, and by what method the requirement was verified. Note: Requirements are often satisfied by design features, and requirements are usually verified by one or more of the following methods: analysis, inspection, and test.
- The verification statement for each payload requirement should include results of the analysis, inspection, and/or test which prove that the requirement has been properly verified.

Safety and Environment (Payload)

This will describe all concerns, research, and solutions to safety issues related to the payload.

- Provide a safety and mission assurance analysis. Provide a Failure Modes and Effects Analysis (which can be as simple as a table of failure modes, causes, effects, and mitigations/controls put in place to minimize the occurrence or effect of the hazard or failure). Discuss likelihood and potential consequences for the top 5 to 10 failures (most likely to occur and/or worst consequences).
- As the program is moving into the operational phase of the Life Cycle, update the listing of personnel hazards, including data demonstrating that safety hazards that will still exist after FRR. Include a table which discusses the remaining hazards and the controls that have been put in place to minimize those safety hazards to the greatest extent possible.
- Discuss any environmental concerns that still exist.

V) Launch Operations Procedures

Checklist

Provide detailed procedure and check lists for the following (as a minimum).

- Recovery preparation
- Motor preparation
- Igniter installation
- Setup on launcher
- Launch procedure
- Troubleshooting
- Postflight inspection

Safety and Quality Assurance

Provide detailed safety procedures for each of the categories in the Launch Operations Procedures checklist. Include the following:

- Provide data demonstrating that risks are at acceptable levels.
- Provide risk assessment for the launch operations, including proposed and completed mitigations.
- Discuss environmental concerns.
- Identify individual that is responsible for maintaining safety, quality and procedures checklists.

VI) Project Plan

Show status of activities and schedule

- Budget plan (in as much detail as possible)
- Funding plan
- Timeline (in as much detail as possible). GANTT charts are encouraged with a discussion of the critical path.
- Educational engagement plan and status

VII) Conclusion

Flight Readiness Review Presentation

Please include the following information in your presentation:

- Launch Vehicle design and dimensions
- Discuss key design features of the launch vehicle
- Motor description
- Rocket flight stability in static margin diagram
- Launch thrust-to-weight ratio and rail exit velocity
- Mass statement
- Parachute sizes and descent rates
- Kinetic energy at key phases of the mission, especially at landing
- Predicted altitude of the launch vehicle with a 5-, 10-, 15-, and 20-mph wind
- Predicted drift from the launch pad with a 5-, 10-, 15-, and 20-mph wind
- Test plans and procedures
- Full-scale flight test. Present and discuss the actual flight test data.
- Recovery system tests
- Summary of Requirements Verification (launch vehicle)
- Payload design and dimensions
- Key design features of the launch vehicle
- Payload integration
- Interfaces with ground systems
- Summary of requirements verification (payload)

The FRR will be presented to a panel that may be comprised of any combination of scientists, engineers, safety experts, education specialists, and industry partners. The team is expected to present and defend the as-built launch vehicle (including the payload), showing that the launch vehicle meets all requirements and mission objectives and that the design can be safely launched and recovered. Upon successful completion of the FRR, the team is given the authority to proceed into the Launch and Operational phases of the life cycle.

It is expected that the **students** deliver the report and answer all questions.

The presentation of the FRR shall be well prepared with a professional overall appearance. This includes, but is not limited to, the following: easy to see slides; appropriate placement of pictures, graphs, and videos; professional appearance of the presenters; speaking clearly and loudly; looking into the camera; referring to the slides, not reading them; and communicating to the panel in an appropriate and professional manner. The slides should be made with dark text on a light background.

Launch Readiness Review (LRR)
Vehicle and Payload Experiment Criteria

The Launch Readiness Review (LRR) will be held by NASA and the National Association of Rocketry (NAR), our launch services provider. These inspections are only open to team members and mentors. These names were submitted as part of your team list. All rockets/payload will undergo a detailed, deconstructive, hands-on inspection. Your team should bring all components of the rocket and payload except for the motor, black powder, and e-matches. Be able to present: anchored flight predictions, anchored drift predictions (15 mph crosswind), procedures and checklists, and Cp and Cg with loaded motor marked on the airframe. The rockets will be assessed for structural, electrical integrity, and safety features. At a minimum, all teams should have:

- An airframe prepared for flight with the exception of energetic materials.
- Data from the previous flight.
- A list of any flight anomalies that occurred on the previous full scale flight and the mitigation actions.
- A list of any changes to the airframe since the last flight.
- Flight simulations.
- Pre-flight check list and Fly Sheet.

A “punch list” will be generated for each team. Items identified on the punch list should be corrected and verified by NAR/NASA on Friday evening. Teams will not be assigned a time on Friday evening, but should come to the hotel to have these items approved. A flight card will be provided to teams, should be completed, and provided at the RSO booth on launch day.

Post-Launch Assessment Review (PLAR)
Vehicle and Payload Experiment Criteria

The PLAR is an assessment of system in-flight performance.

Your PLAR should include the following items at a minimum. Your PLAR should be about 4-15 pages in length.

- Team name
- Motor used
- Brief payload description
- Rocket height
- Rocket diameter
- Rocket mass
- Altitude reached (Feet)
- Vehicle Summary
- Data analysis & results of vehicle
- Payload summary
- Data analysis & results of payload
- Scientific value
- Visual data observed
- Lessons learned
- Summary of overall experience (what you attempted to do versus the results and how you felt your results were; how valuable you felt the experience was)
- Educational Engagement summary
- Budget Summary

Educational Engagement Form

Please complete and submit this form each time you host an educational engagement event.
(Return within 2 weeks of the event end date)

School/Organization name:

Date(s) of event:

Location of event:

Instructions for participant count

Education/Direct Interactions: A count of participants in instructional, hands-on activities where participants engage in learning STEM topic by actively participating in a activity. This includes instructor- led facilitation around an activity regardless of media (e.g. DLN, face-to-face, downlink.etc.). Example: Students learn about Newton's Laws through building an flying a rocket. ***This type of interaction will count towards your requirement for the project.***

Education/Indirect Interactions: A count of participants engaged in learning a STEM topic through instructor-led facilitation or presentation. Example: Students learn about Newton's Laws through PowerPoint presentation.

Outreach/Direct Interaction: A count of participants who do not necessarily learn a STEM topic, but are able to get a hands-on look at STEM hardware. For example, team does a presentation to students about their Student Launch project, brings their rocket and components to the event, and flies a rocket at the end of the presentation.

Outreach/Indirect Interaction: A count of participants that interact with the team. For example: The team sets up a display at the local museum during Science Night. Students come by an talk to the team about their project.

Grade level and number of participants: *(If you are able to break down the participants into grade levels: PreK-4, 5-9, 10-12, an 12+, this will be helpful.)*

Participant's Grade Level	Education		Outreach	
	Direct Interactions	**Indirect** Interactions	**Direct** Interactions	**Indirect** Interactions
K-4				
5-9				
10-12				
12+				
Educators (5-9)				
Educators (other)				

Are the participants with a special group/organization (i.e. Girl Scouts, 4-H, school)? Y N

If yes, what group/organization?

Briefly describe your activities with this group:

Did you conduct an evaluation? If so, what were the results?

Describe how you measured the success of the event.

NASA Project Life Cycle

Charles Pierce
Chief, Spacecraft Propulsion Systems Branch,
NASA - Marshall Space Flight Center

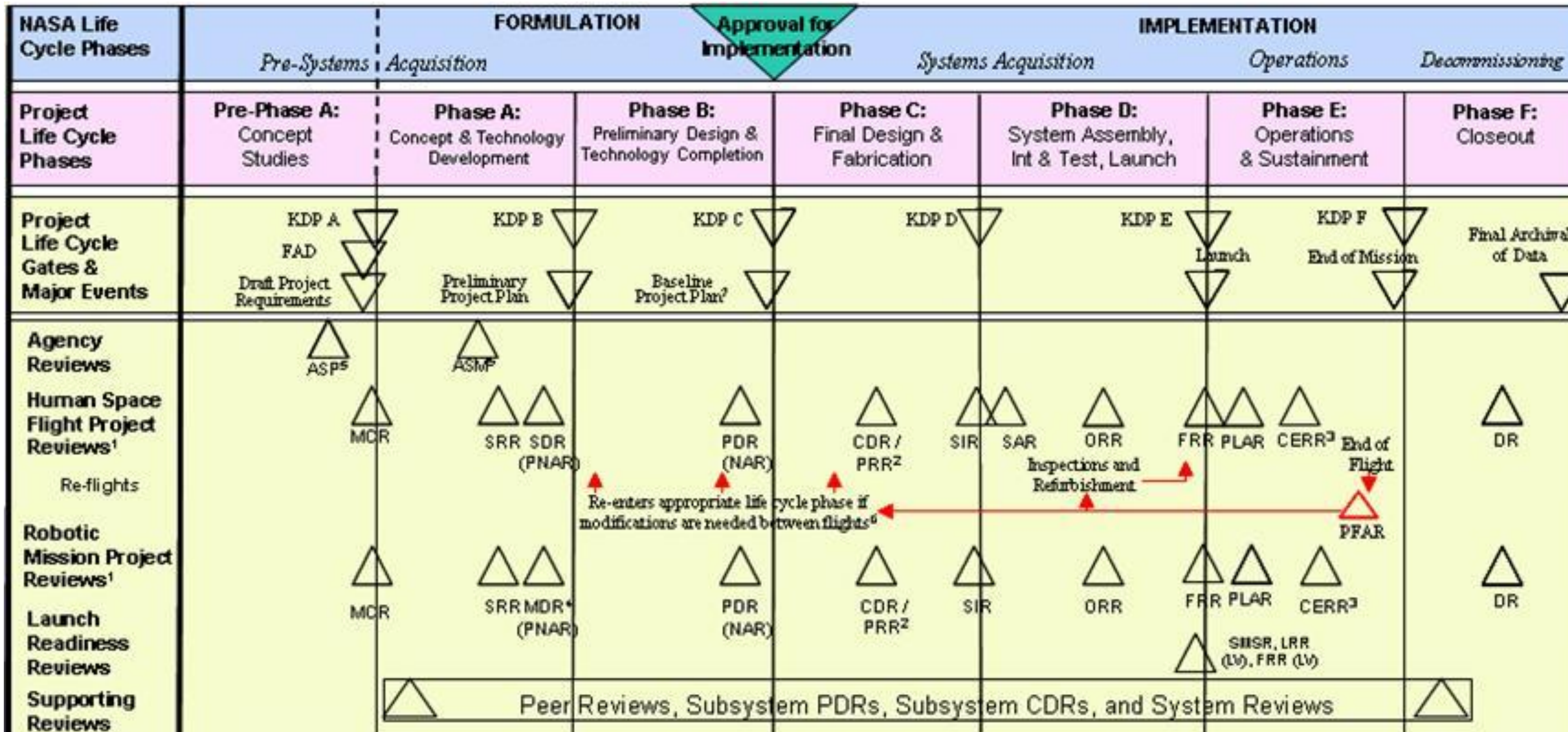
Topics

- Purpose / Objective
- NASA Project Life Cycle (Typical)
- Preliminary Design Review
- Critical (Final) Design Review
- Flight Readiness Review
- Post Flight

Purpose/Objectives of the NASA Project Life Cycle

- Plan for the design, build, verification, flight operations, and disposal of the desired system
- Maintain consistency between projects
- Set expectations for Project Managers, Scientists, & Engineers
  - Plans and Deliverables
  - Fidelity
  - Timing

Typical NASA Project Life Cycle



FOOTNOTES

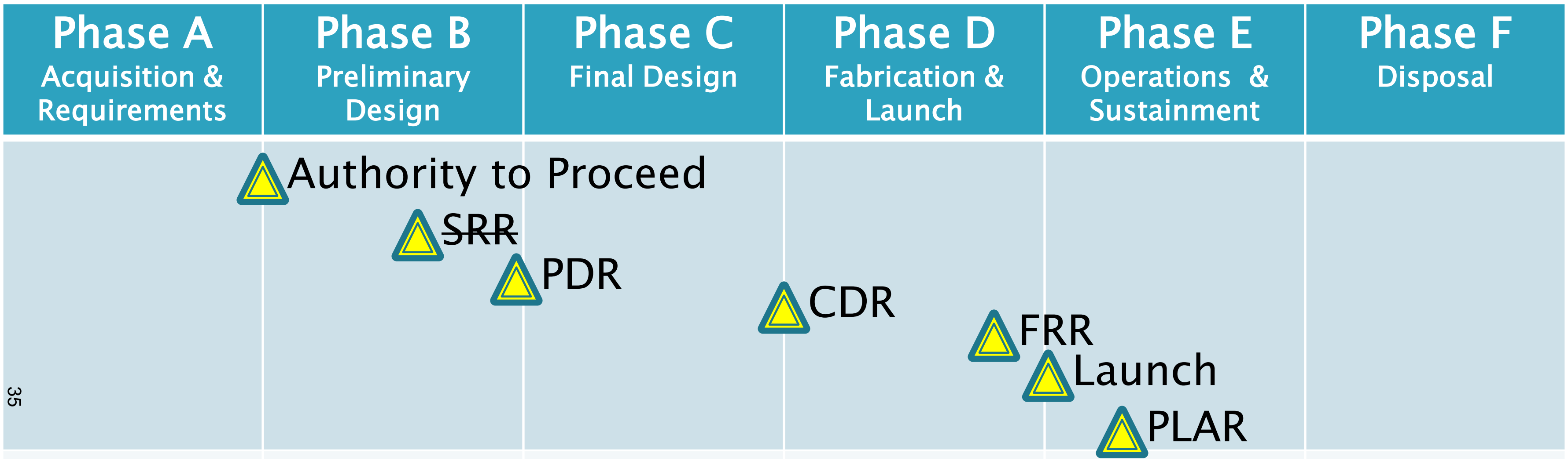
1. Flexibility is allowed in the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan. These reviews are conducted by the project for the independent SRB. See Section 2.5 and Table 2-6.
2. PRR needed for multiple (≥4) system copies. Timing is notional.
3. CERRs are established at the discretion of Program Offices.
4. For robotic missions, the SRR and the MDR may be combined.
5. The ASP and ASM are Agency reviews, not life-cycle reviews.
6. Includes recertification, as required.
7. Project Plans are baselined at KDP C and are reviewed and updated as required, to ensure project content, cost, and budget remain consistent.

ACRONYMS

ASP—Acquisition Strategy Planning Meeting
ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MCR—Mission Concept Review
MDR—Mission Definition Review
NAR—Non-Advocate Review
ORR—Operational Readiness Review
PDR—Preliminary Design Review
PFAR—Post-Flight Assessment Review
PLAR—Post-Launch Assessment Review
PNAR—Preliminary Non-Advocate Review
PRR—Production Readiness Review
SAR—System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRR—System Requirements Review

Reference: NPR 7120.5D, Figure 2-4: “The NASA Project Life Cycle”

NASA Student Launch Life Cycle



- ATP (Authority to Proceed) – Funding is applied to the contract/effort and work performance can begin
- SRR (System Requirements Review) – Top Level Requirements are converted into system requirements. System Requirements are reviewed and authority is given to proceed into Preliminary Design. The NASA Student Launch skips this step. Note: This review is skipped, due to time constraints.
- PDR (Preliminary Design Review) – Preliminary Design is reviewed and authority is given to proceed into Final Design.
- CDR (Critical Design Review) – Final Design is reviewed and authority is given to proceed to build the system.
- FRR (Flight Readiness Review) – As-built design and test data are reviewed and authority is given for Launch.
- PLAR (Post Launch Assessment Report) - Summarize project (cradle to grave), discuss mission results and compare to expected results, document lessons learned.

NASA Project Life Cycle, July 2012

Preliminary Design Review (PDR)

- Objective
  - Prove the feasibility to build and launch the rocket/payload design.
  - Prove that all system requirements will be met.
  - Receive authority to proceed to the Final Design Phase
- Typical Products (Vehicle and Payload)
  - Preliminary Design Discussion
    - Drawings, sketches
    - Identification and discussion of components
    - Analyses (such as Vehicle Trajectory Predictions) and Simulation Results
    - Risks
    - Mass Statement and Mass Margin
  - Schedule from PDR to Launch (including design, build, test)
  - Cost/Budget Statement
  - Mission Profile (Concept of Operations)
  - Interfaces (within the system and external to the system)
  - Test and Verification Plan (for satisfying requirements)
  - Ground Support Equipment Designs/Identification
  - Safety Features

Critical Design Review (CDR)

- Objective
  - Complete the final design of the rocket/payload system
  - Receive authority to proceed into Fabrication and Verification phase
    - In a perfect world, fabrication/procurement of the final system wouldn't begin until a successful completion of CDR.
    - Due to schedule constraints, however, it is often necessary to start procurements and fabrication prior to CDR.
    - Procurements and Fabrication that start prior to CDR add an extra risk to the Project because design issues may be discovered at CDR that impact procurements or fabrication.
- Typical Products (Vehicle and Payload)
  - PDR Deliverables (matured to reflect the final design)
  - Report and discuss completed tests
  - Procedures and Checklists

Flight Readiness Review (FRR)

- Objective
  - Prove that the Rocket/Payload System has been fully built, tested, and verified to meet the system requirements
  - Prove that all system requirements have been, or will be, met
  - Receive authority to proceed to Launch
- Typical Products (Vehicle and Payload)
  - Schedule
  - Cost Statement
  - Design Overview
    - Key components
    - Key drawings and layouts
    - Trajectory and other key analyses
    - Key Safety Features
    - Mass Statement
    - Remaining Risks
  - Mission Profile
  - Presentation and analysis and models (use real test data)
  - System Requirements Verification
  - Ground Support Equipment
  - Procedures and Check Lists

Hardware Inspections (Hands on)

- Objective
  - To perform a hands-on final inspection of the rocket system, prior to launch
  - Performed by the operators of the Launch Range
- Process
  - Rockets deconstructed
    - Mechanical components pulled and twisted
    - Electronics and Wiring inspected (as much as possible)
    - Recovery System fully inspected
  - Questions asked
    - Arming, Activation, Execution Sequences
    - Rocket and Payload Functions
  - Launch Day Procedures reviewed
  - Questions Answered (anything about Launch Day or Range Operations)
  - Actions given to repair unsafe elements in the rocket system (if any are found)

- Note: This inspection is a Pre Range Safety Officer (RSO) inspection.
  - It occurs one day before launch and it purpose is to give the Student Teams an opportunity to correct hardware issues that could otherwise result in the denial of launch of their rocket.
  - A final RSO inspection will occur at the launch site (just like a normal NAR/TRA RSO Inspection at the launch site).

Post Launch Assessment Report

- Summary of the Project
- Summary of the Vehicle and Payload
  - Especially note anything that changed after FRR
- Presentation of Vehicle and Payload Results
  - Comparison to predicted results
  - Discussion of anomalies
- Lessons Learned

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Safety

High Power Rocket Safety Code
Provided by the National Association of Rocketry

1. **Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.

2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.

3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.

4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the “off” position when released. If my rocket has onboard ignition systems for motors or recovery devices, these will have safety interlocks that interrupt the current path until the rocket is at the launch pad.

5. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

6. **Launch Safety.** I will use a 5-second countdown before launch. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, and that a means is available to warn participants and spectators in the event of a problem. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.

7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 if the rocket motor being launched uses titanium sponge in the propellant.

8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.

9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater.

11. **Launcher Location.** My launcher will be at least one half the minimum launch site dimension, or 1500 feet (whichever is greater) from any inhabited building, or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

Minimum Distance Table

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	Minimum Personnel Distance (Complex Rocket) (ft.)
0 – 320.00	H or smaller	50	100	200
320.01 – 640.00	I	50	100	200
640.01 – 1,280.00	J	50	100	200
1,280.01 – 2,560.00	K	75	200	300
2,560.01 – 5,120.00	L	100	300	500
5,120.01 – 10,240.00	M	125	500	1000
10,240.01 – 20,480.00	N	125	1000	1500
20,480.01 – 40,960.00	O	125	1500	2000

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors
Revision of July 2008
Provided by the National Association of Rocketry (www.nar.org)

Failures, Hazards and Risk

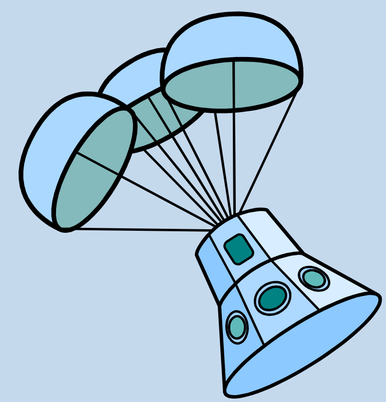
How to Identify, Track and Mitigate

Examples from Home

- Getting to work on time ("mission success")
  - **Risks**: weather, traffic jam, alarm doesn't ring
    - How do we plan for these risks?
  - **Failure**: the car doesn't start
    - How do we try to make sure that it will start?
  - **Hazard**: bad roads, other drivers, sudden changes in traffic flow
    - How do we plan for this and avoid problems?
- Getting to work on time means that we have recognized the risks, failure modes, and hazards, and have taken action to reduce their probability and impact.
- This same approach improves the probability of success for a project.

Risk Definition

- The combination of the probability of an undesired event and the consequences, impact, or severity of the event.
- Risk assessment includes
  - What can go wrong
  - How likely is it to occur
  - What the consequences are
- Risk Mitigation is
  - Application of methods to lessen the probability and/or impact of the undesired event



Examples of Risk

- Planned design will be over budget
- Key personnel will leave the program
- Unavailability of equipment when needed to support schedule
- Students have many other demands on time and do not have time to finish the project
- Parts unavailability
- Mishaps
- Communication issues
- Bad weather on launch day

Risk Management

- “Risk management is a continuous process that
  - identifies risks;
  - analyzes their impact and prioritizes them;
  - develops and carries out plans for risk mitigation or acceptance;
  - tracks risks and the implementation of mitigation plans;
  - supports informed, timely, and effective decisions to control risks and mitigation plans;
  - and assures that risk information is communicated and documented.
  - Risk management is driven by established success criteria and is performed by the whole team”
  - (from NASA Program and Project Management Processes and Requirements)

Examples of Tables to Include in PDR, CDR, FRR

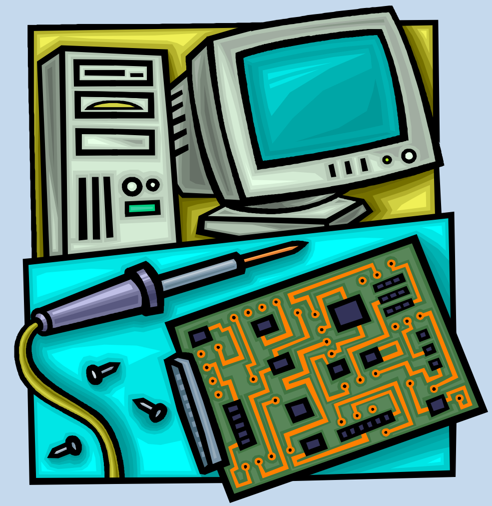
Risk	Probability	Impact	Mitigation
Project falls behind schedule due to multiple demands on time	Highly probable	Late delivery of PDR, CDR, FRR; incomplete project	Create a schedule with margin for problems, track progress; divide work among team
Parts are unavailable	Probability is low	Last minute design changes	Have design options and multiple sources; finalize design and order parts early
Key personnel leave project	Probability is low	Extra work for members; late delivery; incomplete project	Have primary and backup assignments; document activities; communicate
Project is over budget	Highly probable	Last minute design changes for cost cutting; incomplete project	Track progress; have multiple funding sources

Failures

- During the rocket design process, each component and system should be analyzed for failure modes:
  - How can it fail
  - What are the consequences of the failure
  - How can the failure be prevented
- This includes system integration and ground support equipment, as well as the rocket and payload
- Document the analysis and update as necessary

Failure Examples

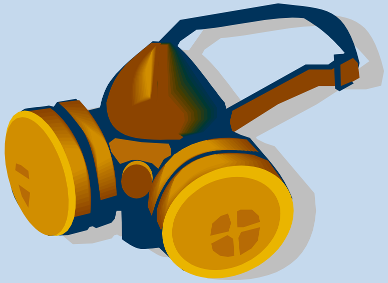
- Parachutes fail to deploy
- Failure to ignite
- Unstable flight
- Failure to collect data
- Power loss



Examples of Tables to Include in PDR, CDR, FRR

Failure Modes and Effects Analysis of Propulsion System
Propulsion Team: Daniel Chhitt, Jason Back

Function	*Potential Failure Mode*	*Potential Effects of Failure*	*Failure Prevention*
1	Propellant fails to ignite.	Total mission failure, rocket does not take off.	Proper ignition system setup.
2	Propellant ignites but extinguishes before desired burn time.	Rocket may not reach desired height, payload failure.	Proper motor and propellant inspection and testing.
3	Motor mounting fails and motor launches through the rocket.	Possible destruction of all systems; avionics, recovery, payload	Proper motor mounting structure and load testing of mounting structure.
4	Propellant ignites but causes a catastrophic explosion.	Possible destruction of all systems; avionics, recovery, payload, structure.	Proper motor and propellant inspection and testing.
5	Propellant ignites but burns through motor casing.	Severe loss of stability, possible destruction of all systems.	Proper testing of motor casing and propellant.
6	Motor casing becomes detached during flight.	Rocket may not reach desired height, motor becomes a projectile.	Proper testing and mounting of motor casing to the structure.



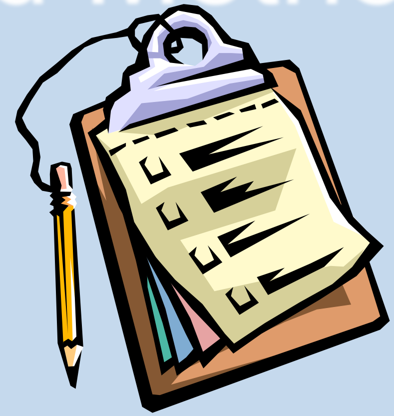
Hazards

- The project can be done safely and successfully, but a few hazards must be clearly recognized, understood, and mitigated.
- Safety of the students is NASA’s first priority and must never be compromised.
- There are many resources available to help with this concern.

Hazard Examples

- Adhesives, solvents, and paint
- Black Powder and solid propellant
- Use of Tools
- Launch site failures
- Pressurized/cold hybrid systems
- Other hazards associated with a particular design

Safety Resources and Methods



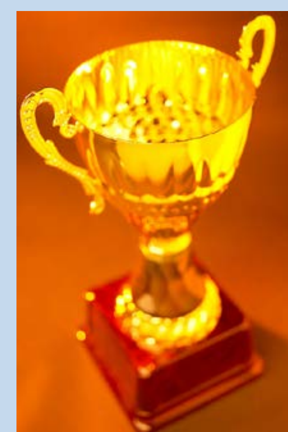
- NAR Safety Codes and Mentors
- NAR certifications and training
- Material Safety Data Sheets
- Operators Manuals
- Development and adherence to assembly and launch procedures
- Equipment, such as goggles, gloves, sturdy shoes, hard hats, cotton clothing, fire extinguishers
- Environment, such as good ventilation, restricting cell phones around electric matches
- Planning and communication; designate someone responsible to look at activities from a safety perspective
- Use the buddy system

Examples of Tables to Include in PDR, CDR, FRR

Hazard	Effect of Hazard	Mitigation
Chemicals in paint, solvent, adhesive	Possible respiratory and skin irritation	Read MSDS for precautions; wear gloves; have good ventilation
Ignition of black powder or other pyrotechnic or explosive compounds	Fire, damage to equipment, personal injury	Follow safety rules; wear cotton clothing; do not smoke or have other static or spark producing items in the area
Use of power tools	Cuts or other injuries, damage to equipment, flying debris	Follow manufacturer's safety instructions; wear goggles; do not operate without supervision
Misfire, hangfire on launch pad	Rocket may not be safe to approach	Write procedures to plan for this contingency and follow; be patient and wait; consult with experts

Mission Success

- Mission Success is the result of attention to detail, and a thorough, honest assessment of risks, failure modes and hazards.
- Failure is often the best teacher, so plan to test as much as possible.
- Teamwork and communication are essential for a successful project.



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Understanding MSDS’s

By: Jeff Mitchell

MSFC Environmental Health

What is an MSDS?

- A Material Safety Data Sheet (MSDS) is a document produced by a manufacturer of a particular chemical and is intended to give a comprehensive overview of how to safely work with or handle this chemical

What is an MSDS?

- MSDS's do not have a standard format, but they are all required to have certain information per OSHA 29 CFR 1910.1200
- Manufacturers of chemicals fulfill the requirements of this OSHA standard in different ways

Required data for MSDS’s

- Identity of hazardous chemical
- Chemical and common names
- Physical and chemical characteristics
- Physical hazards
- Health hazards
- Routes of entry
- Exposure limits

Required data for MSDS’s (Cont.)

- Carcinogenicity
- Procedures for safe handling and use
- Control measures
- Emergency and First-aid procedures
- Date of last MSDS update
- Manufacturer’s name, address, and phone number

Important Agencies

- ACGIH
  - The American Conference of Governmental Industrial Hygienist develop and publish occupational exposure limits for many chemicals, these limits are called TLV’s (Threshold Limit Values)

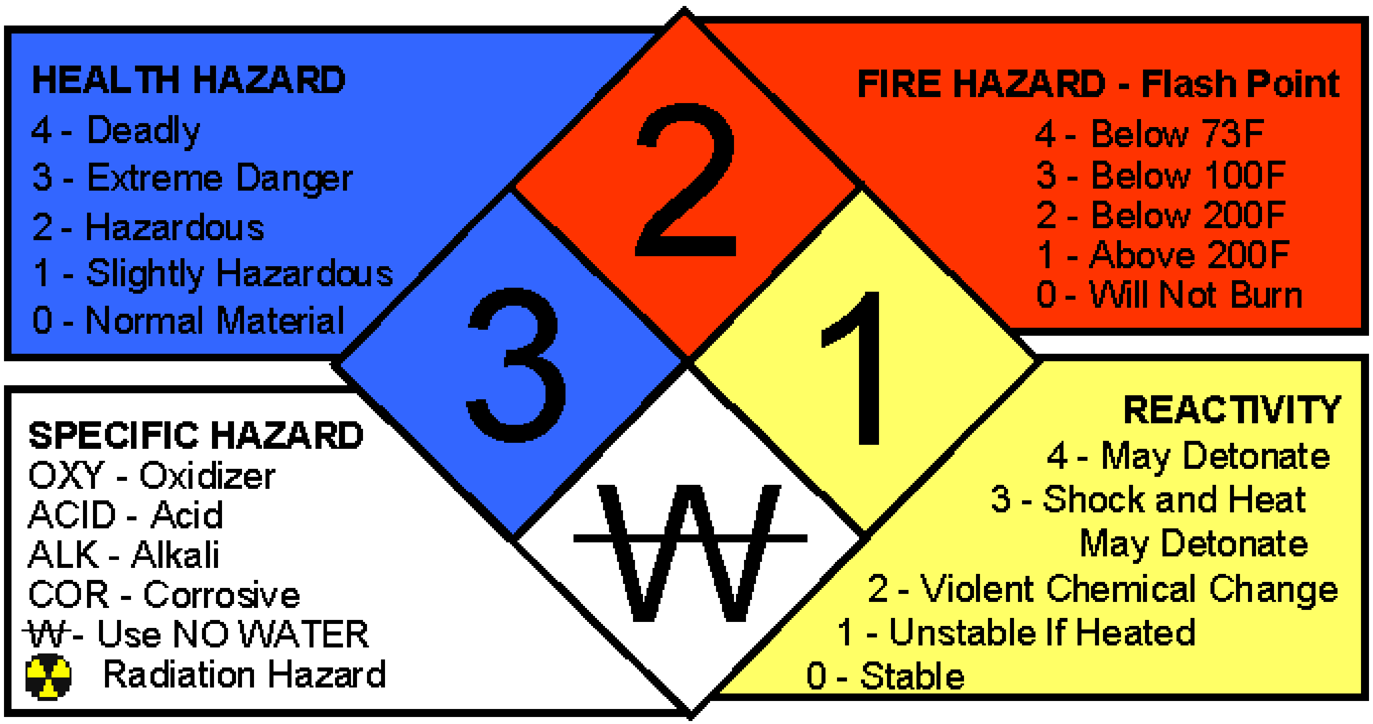
Important Agencies (Cont.)

- ANSI
  - The American National Standards Institute is a private organization that identifies industrial and public national consensus standards that relate to safe design and performance of equipment and practices

Important Agencies (Cont.)

- NFPA
  - The National Fire Protection Association, among other things, established a rating system used on many labels of hazardous chemicals called the NFPA Diamond
  - The NFPA Diamond gives concise information on the Health hazard, Flammability hazard, Reactivity hazard, and Special precautions
  - An example of the NFPA Diamond is on the next slide

NFPA Diamond



Important Agencies (Cont.)

- NIOSH
  - The National Institute of Occupational Safety and Health is an agency of the Public Health Service that tests and certifies respiratory and air sampling devices. It also investigates incidents and researches occupational safety

Important Agencies (Cont.)

- OSHA
  - The Occupational Safety and Health Administration is a Federal Agency with the mission to make sure that the safety and health concerns of all American workers are being met

Exposure Limits

- Occupational exposure limits are set by different agencies
- Occupational exposure limits are designed to reflect a safe level of exposure
- Personnel exposure above the exposure limits is not considered safe

Exposure Limits (Cont.)

- OSHA calls their exposure limits, PEL's, which stands for Permissible Exposure Limit
  - OSHA PEL's rarely change
- ACGIH, establishes TLV's, which stands for Threshold Limit Values
  - ACGIH TLV's are updated annually

Exposure Limits (Cont.)

- A Ceiling limit (noted by C) is a concentration that shall never be exceeded at any time
- An IDLH atmosphere is one where the concentration of a chemical is high enough that it may be <u>I</u>mmediately <u>D</u>angerous to <u>L</u>ife and <u>H</u>ealth

Exposure Limits (Cont.)

- A STEL, is a <u>S</u>hort <u>T</u>erm <u>E</u>xposure Limit and is used to reflect a 15 minute exposure time
- A TWA, is a <u>T</u>ime <u>W</u>eighted <u>A</u>verage and is used to reflect an 8 hour exposure time

Chemical and Physical Properties

- Boiling Point
  - The temperature at which the chemical changes from liquid phase to vapor phase
- Melting Point
  - The temperature at which the chemical changes from solid phase to liquid phase
- Vapor Pressure
  - The pressure of a vapor in equilibrium with its non-vapor phases. Most often the term is used to describe a liquid’s tendency to evaporate
- Vapor Density
  - This is used to help determine if the vapor will rise or fall in air
- Viscosity
  - It is commonly perceived as "thickness", or resistance to pouring. A higher viscosity equals a thicker liquid

Chemical and Physical Properties (Cont.)

- Specific Gravity
  - This is used to help determine if the liquid will float or sink in water
- Solubility
  - This is the amount of a solute that will dissolve in a specific solvent under given conditions
- Odor threshold
  - The lowest concentration at which most people may smell the chemical
- Flash point
  - The lowest temperature at which the chemical can form an ignitable mixture with air
- Upper (UEL) and lower explosive limits (LEL)
  - At concentrations in air below the LEL there is not enough fuel to continue an explosion; at concentrations above the UEL the fuel has displaced so much air that there is not enough oxygen to begin a reaction

Things you should learn from MSDS's

- Is this chemical hazardous?
  - Read the Health Hazard section
- What will happen if I am exposed?
  - There is usually a section called Symptoms of Exposure under Health Hazard
- What should I do if I am overexposed?
  - Read Emergency and First-aid procedures
- How can I protect myself from exposure?
  - Read Routes of Entry, Procedures for safe handling and use, and Control measures

Take your time!

- Since MSDS's don't have a standard format, what you are seeking may not be in the first place you look
- Study your MSDS's before there is a problem so you aren't rushed
- Read the entire MSDS, because information in one location may compliment information in another

The following slides are an abbreviated version of a real MSDS

Study it and become more familiar with this chemical

MSDS: METHYL ETHYL KETONE

Abbreviated MSDS

SECTION 1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MDL INFORMATION SYSTEMS, INC.
14600 CATALINA STREET
1-800-635-0064 OR
1-510-895-1313

Manufacturer name
and phone #

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 USA

CAS NUMBER: 78-93-3
RTECS NUMBER: EL6475000
EU NUMBER (EINECS):
201-159-0
EU INDEX NUMBER:
606-002-00-3

SUBSTANCE: METHYL ETHYL KETONE

Last revision

TRADE NAMES/SYNONYMS:
BUTANONE; 2-BUTANONE; ETHYL METHYL KETONE; METHYL ACETONE; 3-BUTANONE; MEK; SCOTCH-GRIP ® BRAND SOLVENT #3 (3M); STOP, SHIELD, PEEL REDUCER (PYRAMID PLASTICS, INC.); STABOND C-THINNER (STABOND CORP.); OATEY CLEANER (OATEY COMPANY); RCRA U159; UN1193; STCC 4909243; C4H8O; OHS14460

CHEMICAL FAMILY:
Ketones, aliphatic

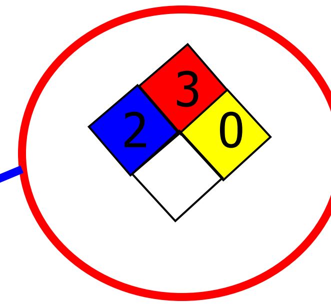
CREATION DATE: Sep 28 1984
REVISION DATE: Mar 30 1997

SECTION 2. COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: METHYL ETHYL KETONE
CAS NUMBER: 78-93-3
PERCENTAGE: 100

SECTION 3. HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): Health=2 Fire=3 Reactivity=0



Good info for labeling containers

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: liquid
ODOR: minty, sweet odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire

POTENTIAL HEALTH EFFECTS:

What happens when exposed?

INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, difficulty breathing,

SKIN CONTACT:

SHORT TERM EXPOSURE: irritation

LONG TERM EXPOSURE: same as effects reported in short term exposure

EYE CONTACT…

INGESTION…

CARCINOGEN STATUS:

OSHA: N

NTP: N

IARC: N

Does it cause cancer?

SECTION 4. FIRST AID MEASURES

INHALATION…

SKIN CONTACT…

EYE CONTACT…

INGESTION…

What should you do if exposed?

SECTION 5. FIRE FIGHTING MEASURES

SECTION 6. ACCIDENTAL RELEASE MEASURES

AIR RELEASE:
Reduce vapors with water spray
SOIL RELEASE:
Dig holding area such as lagoon, pond or pit for containment. Absorb with…

SECTION 7. HANDLING AND STORAGE

Store and handle in accordance …

SECTION 8. EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
METHYL ETHYL KETONE:
METHYL ETHYL KETONE:
200 ppm (590 mg/m3) OSHA TWA
300 ppm (885 mg/m3) OSHA STEL
200 ppm (590 mg/m3) ACGIH TWA
300 ppm (885 mg/m3) ACGIH STEL

8 hr avg

15 min avg

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

COLOR: colorless
PHYSICAL FORM: liquid
ODOR: minty, sweet odor
MOLECULAR WEIGHT: 72.12
MOLECULAR FORMULA: C-H3-C-H2-C-O-C-H3
BOILING POINT: 176 F (80 C)
FREEZING POINT: -123 F (-86 C)
VAPOR PRESSURE: 100 mmHg @ 25 C
VAPOR DENSITY (air = 1): 2.5
SPECIFIC GRAVITY (water = 1): 0.8054
WATER SOLUBILITY: 27.5%
PH: No data available
VOLATILITY: No data available
ODOR THRESHOLD: 0.25-10 ppm
EVAPORATION RATE: 2.7 (ether = 1)
VISCOSITY: 0.40 cP @25 C
SOLVENT SOLUBILITY: alcohol, ether, benzene, acetone, oils, solvents

MYTH: if it smells bad it is harmful, if it smells good it is safe

MEK vapor is heavier than air

MEK liquid will float on stagnant water

Not very soluble in water

Will likely smell MEK before being overexposed

Goes to vapor easy

SECTION 10. STABILITY AND REACTIVITY

SECTION 11. TOXICOLOGICAL INFORMATION

MSDS's have an abundance of information useful in many different aspects

SECTION 12. ECOLOGICAL INFORMATION

SECTION 13. DISPOSAL CONSIDERATIONS

SECTION 14. TRANSPORT INFORMATION

SECTION 15. REGULATORY INFORMATION

SECTION 16. OTHER INFORMATION

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Awards

NASA Student Launch Awards

Award:	Award Description:	Determined by:	When awarded:
Vehicle Design Award	Awarded to the team with the most creative and innovative overall vehicle design for their intended payload while still maximizing safety and efficiency.	Review Panel	Launch Day
Payload Design Award	Awarded to the team with the most creative and innovative payload design while maximizing safety and science value.	Review Panel	Launch Day
Safety Award	Awarded to the team that demonstrates the highest level of safety according to the scoring rubric..	Review Panel	Launch Day
Project Review (CDR/FRR) Award	Awarded to the team that is viewed to have the best combination of written reviews and formal presentations	Review Panel	Launch Day
Educational Engagement Award	Awarded to the team that is determined to have best inspired the study of rocketry and other science, technology, engineering, and math (STEM) related topics in their community. This team not only presented a high number of activities to a large number of people, but also delivered quality activities to a wide range of audiences.	Review Panel	Launch Day
Web Design Award	Awarded to the team that has the best, most efficient Web site with all documentation posted on time.	Review Panel	Launch Day
Altitude Award	Awarded to the team that achieves the best altitude score according to the scoring rubric and listed requirements.	Review Panel	Launch Day
Best Looking Rocket	Awarded to the team that is judged by their peers to have the “Best Looking Rocket”	Peer Review	Launch Day
Best Team Spirit Award	Awarded to the team that is judged by their peers to display the “Best Team Spirit” on launch day.	Peer Review	Launch Day
Rookie Award	Awarded to the top overall rookie team using the same criteria as the Overall Winner Award. (Only given if the overall winner is not a rookie team).	Review Panel	June 13, 2014
Overall Winner	Awarded to the top overall team. Design reviews, outreach, Web site, safety, and a successful flight will all factor into the Overall Winner.	Review Panel	June 13, 2014

National Aeronautics and Space Administration

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